Chapter 13

Knowledge Discovery Systems:
Systems That Create Knowledge
Chapter Objectives

• To explain how knowledge is discovered
• To describe knowledge discovery systems, including design considerations, and how they rely on mechanisms and technologies
• To explain data mining (DM) technologies
• To discuss the role of DM in customer relationship management
Knowledge Synthesis through Socialization

- To discover tacit knowledge
- Socialization enables the discovery of tacit knowledge through joint activities
  - between masters and apprentices
  - between researchers at an academic conference
Another name for Knowledge Discovery in Databases is data mining (DM).

Data mining systems have made a significant contribution in scientific fields for years.

The recent proliferation of e-commerce applications, providing reams of hard data ready for analysis, presents us with an excellent opportunity to make profitable use of data mining.
Data Mining Techniques Applications

- **Marketing** – Predictive DM techniques, like artificial neural networks (ANN), have been used for *target marketing* including market segmentation.

- **Direct marketing** – customers are likely to respond to new products based on their previous consumer behavior.

- **Retail** – DM methods have likewise been used for *sales forecasting*.

- **Market basket analysis** – uncover which products are likely to be purchased together.
Data Mining Techniques
Applications

- **Banking** – *Trading* and *financial forecasting* are used to determine derivative securities pricing, futures price forecasting, and stock performance.
- **Insurance** – DM techniques have been used for segmenting customer groups to determine *premium pricing* and predict *claim* frequencies.
- **Telecommunications** – Predictive DM techniques have been used to attempt to reduce churn, and to predict when customers will attrition to a competitor.
- **Operations management** – Neural network techniques have been used for planning and scheduling, project management, and quality control.
1. **Business Understanding** – To obtain the highest benefit from data mining, there must be a clear statement of the business objectives.

2. **Data Understanding** – Knowing the data well can permit the designer to tailor the algorithm or tools used for data mining to his/her specific problem.

3. **Data Preparation** – Data selection, variable construction and transformation, integration, and formatting

4. **Model building and validation** – Building an accurate model is a trial and error process. The process often requires the data mining specialist to iteratively try several options, until the best model emerges.

5. **Evaluation and interpretation** – Once the model is determined, the validation dataset is fed through the model.

6. **Deployment** – Involves implementing the ‘live’ model within an organization to aid the decision making process.

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CRISP-DM Data Mining Process Methodology
1. Business Understanding process

a. **Determine Business objectives** – To obtain the highest benefit from data mining, there must be a clear statement of the business objectives.

b. **Situation Assessment** – The majority of the people in a marketing campaign who receive a target mail, do not purchase the product.

c. **Determine Data Mining Goal** – Identifying the most likely prospective buyers from the sample, and targeting the direct mail to those customers, could save the organization significant costs.

d. **Produce Project Plan** – This step also includes the specification of a project plan for the DM study.
2. Data Understanding process

a. **Data collection** – Defines the data sources for the study, including the use of external public data, and proprietary databases.

b. **Data description** – Describes the contents of each file or table. Some of the important items in this report are: number of fields (columns) and percent of records missing.

c. **Data quality and verification** – Define if any data can be eliminated because of irrelevance or lack of quality.

d. **Exploratory Analysis of the Data** – Use to develop a hypothesis of the problem to be studied, and to identify the fields that are likely to be the best predictors.
3. Data Preparation process

a. **Selection** – Requires the selection of the predictor variables and the sample set.

b. **Construction and transformation of variables** – Often, new variables must be constructed to build effective models.

c. **Data integration** – The dataset for the data mining study may reside on multiple databases, which would need to be consolidated into one database.

d. **Formatting** – Involves the reordering and reformatting of the data fields, as required by the DM model.
4. Model building and Validation process

a. **Generate Test Design** – Building an accurate model is a trial and error process. The data mining specialist iteratively try several options, until the best model emerges.

b. **Build Model** – Different algorithms could be tried with the same dataset. Results are compared to see which model yields the best results.

c. **Model Evaluation** – In constructing a model, a subset of the data is usually set-aside for validation purposes. The validation data set is used to calculate the accuracy of predictive qualities of the model.
5. Evaluation and Interpretation process

a. **Evaluate Results** – Once the model is determined, the predicted results are compared with the actual results in the validation dataset.

b. **Review Process** – Verify the accuracy of the process.

c. **Determine Next Steps** – List of possible actions decision.
6. Deployment process

a. **Plan Deployment** – This step involves implementing the ‘live’ model within an organization to aid the decision making process.

b. **Produce Final Report** – Write a final report.

c. **Plan Monitoring and Maintenance** – Monitor how well the model predicts the outcomes, and the benefits that this brings to the organization.

d. **Review Project** – Experience, and documentation.
The Iterative Nature of the KDD process
1. Predictive Techniques
   - **Classification:** Data mining techniques in this category serve to classify the discrete outcome variable.
   - **Prediction or Estimation:** DM techniques in this category predict a continuous outcome (as opposed to classification techniques that predict discrete outcomes).

2. Descriptive Techniques
   - **Affinity or association:** Data mining techniques in this category serve to find items closely associated in the data set.
   - **Clustering:** DM techniques in this category aim to create clusters of input objects, rather than an outcome variable.
Web Data Mining - Types

1. **Web structure mining** – Examines how the Web documents are structured, and attempts to discover the model underlying the link structures of the Web.
   - *Intra-page structure mining* evaluates the arrangement of the various HTML or XML tags within a page
   - *Inter-page structure* refers to hyper-links connecting one page to another.

2. **Web usage mining** (*Clickstream Analysis*) – Involves the identification of patterns in user navigation through Web pages in a domain.
   - Processing, Pattern analysis, and Pattern discovery

3. **Web content mining** – Used to discover what a Web page is about and how to uncover new knowledge from it.
Data Mining and Customer Relationship Management

- CRM is the mechanisms and technologies used to manage the interactions between a company and its customers.
- The data mining prediction model is used to calculate a score: a numeric value assigned to each record in the database to indicate the probability that the customer represented by that record will behave in a specific manner.
Barriers to the use of DM

- Two of the most significant barriers that prevented the earlier deployment of knowledge discovery in the business relate to:
  - Lack of data to support the analysis
  - Limited computing power to perform the mathematical calculations required by the DM algorithms.
Case Study

- An application of Rule Induction to real estate appraisal systems
  - In this case, we seek specific knowledge that we know can be found in the data in databases, but which can be difficult to extract.
  - Procedure to create the decision tree:
    - Data preparation and preprocessing
    - Tree construction
    - House pruning
    - Paired leaf analysis
Case Study
An application of Rule Induction to real estate appraisal systems

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Induction Results</th>
<th>Expert Estimate</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Living Area</td>
<td>$15 - $31</td>
<td>$15 - $25</td>
<td>0 - 2.4%</td>
</tr>
<tr>
<td>Bedrooms</td>
<td>$4311 - $5212</td>
<td>$2500 - $3500</td>
<td>49 - 72%</td>
</tr>
<tr>
<td>Bathrooms</td>
<td>$3812 - $5718</td>
<td>$1500 - $2000</td>
<td>154 - 186%</td>
</tr>
<tr>
<td>Garage</td>
<td>$3010 - $4522</td>
<td>$3000 - $3500</td>
<td>0.3 - 29%</td>
</tr>
<tr>
<td>Pool</td>
<td>$7317 - $11697</td>
<td>$9000 - $12000</td>
<td>2.5 - 19%</td>
</tr>
<tr>
<td>Fireplace</td>
<td>$1500 - $4180</td>
<td>$1200 - $2000</td>
<td>25 - 109%</td>
</tr>
<tr>
<td>Year Built</td>
<td>1.2 - 1.7%</td>
<td>1.0 - 1.2%</td>
<td>20 - 42%</td>
</tr>
</tbody>
</table>

Summary of Induction Results
Case Study

An application of Rule Induction to real estate appraisal systems

Partial Decision Tree Results for Real Estate Appraisal

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Case Study

• An application of Web Content mining to Expertise Locator Systems
  ♦ NASA Expert Seeker Web Miner demo
  ♦ A KM system that locates experts based on published documents requires:
    • Automatic method for identifying employee names.
    • A method to associate employee names with skill keywords embedded in those documents.
Conclusions

In this Chapter we:

• Described knowledge discovery systems, including design considerations, and how they rely on mechanisms and technologies
• Learned how knowledge is discovered:
  ♦ Through through socialization with other knowledgeable persons
  ♦ Trough DM by finding interesting patterns in observations, typically embodied in explicit data
• Explained data mining (DM) technologies
• Discussed the role of DM in customer relationship management
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Systems That Create Knowledge